City of Corvallis Salmon Response Plan

Chapter 8. Monitoring/Reporting

Prepared for:

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Disclaimer

The authors have attempted to replace all references to Squaw Creek with the creek's new name, Dunawi Creek. This includes replacing the creek's full name as well as changing Squaw Creek Reach reference labels to indicate Dunawi Creek.

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CHAPTER 8. MONITORING/REPORTING

INTRODUCTION

The ESA Section 4(d) Rules require that any application for certification under this section must include a mechanism for monitoring the effectiveness of the program. NOAA Fisheries is explicit in its publication of the ESA Section 4(d) Rules:

''NMFS [NOAA Fisheries] will evaluate on a regular basis the effectiveness of the program in protecting and achieving a level of salmonid productivity and/or habitat function consistent with the conservation of the listed salmonids. If a program does not meet its objectives, NMFS [NOAA Fisheries] will work with the relevant jurisdiction to adjust the program accordingly. If the responsible entity chooses not to adjust the program accordingly, NMFS [NOAA Fisheries] will publish notification in the **Federal Register** and announce that the program will no longer be free from ESA take prohibitions because it does not sufficiently conserve listed salmonids." (Federal Register, July 10, 2000, page 42426)

The monitoring program that is developed for the Salmon Response Plan does the following:

- Measures progress of the implemented activities under the Salmon Response Plan.
- Compares progress to stated goals in the Salmon Response Plan to quantify progress, and depending on degree of progress either,
    - Determines that the implementation activities are meeting goals, or
    - Determines that the implementation activities are not meeting goals.
- Reports implementation activities to NOAA Fisheries.

If monitoring determines that implementation activities are not meeting the Salmon Response Plan goals of protecting Chinook salmon habitat, the monitoring report to NOAA Fisheries must outline the pro-active steps to be taken to modify implementation activities that will bring the plan into alignment with the goals.

Corrections to the implementation activities will incorporate an "adaptive management" approach, which requires the City to modify its Salmon Response Plan as it becomes more knowledgeable of those activities that may or may not meet the plan goals. Directions are provided in the ESA Section 4(d) Rules Guidance Manual, which states that where monitoring indicates the need for program modification the plan should include "a method for using monitoring information to change actions when needed [through an] adaptive management" approach (National Marine Fisheries Service Northwest and Southwest Regions September 22, 2000, page 8).

In addition to the mandatory requirement that the monitoring plan has to fulfill the certification process, it will also function as a practical document that the City will use internally to measure progress. Importantly it will be used by to document for City officials and the public progress toward meeting the plan's goals. In that capacity it will become the official statement on the program's ability to further prevent habitat degradation and to restore PFC. Where plan deviations are identified, it will be used as a tool to outline the pro-active steps to be taken to correct plan deviations in order to keep the plan on track.

Monitoring Plan Format, Frequency and Content

NOAA Fisheries does not state monitoring frequency or the report format to be submitted. The ESA Section 4(d) Rule Guidance only requires that the jurisdiction have a plan and "a schedule for conducting monitoring and submitting reports."

The monitoring plan submission should be a formal report to NOAA Fisheries. It should contain only the information necessary to demonstrate how the plan is meeting the main and legal objective of preventing further habitat degradation. It should also demonstrate, as the plan becomes capable of doing so, that it is meeting the secondary objective of putting the City on a trajectory of restoring PFC.

Given the nature of what is to be monitored and the cycle of assessment that will need to be developed, the monitoring program should be conducted on an annual basis for the following reasons:

- Programmatic Monitoring activities
    - Many activities rely on an annual funding and budgeting cycle.
    - Other related activities and programs have annual reporting requirements that can be incorporated into this monitoring plan.
    - Annual monitoring is a useful time period to develop trend lines for annual comparisons.
- Scientific monitoring
    - Much of the scientific monitoring will need to be conducted on an annual basis and some of it even more frequently in order for there to be data collection and measurement consistency.
    - Other related activities have annual data collection and evaluation requirements that can be incorporated into this monitoring plan.
    - Annual monitoring is a useful time period to develop trend lines for annual comparisons.

The monitoring plan described in this chapter has two elements. The first is the programmatic element. Monitoring will evaluate the programs and program implementation outlined in the plan. It will focus on overall program development and implementation that will take place during the life of the plan. Since the plan is a comprehensive, cross departmental effort to prevent further Chinook salmon habitat degradation and restore PFC, there are a complex series of activities to be implemented over the plan's life. The programmatic element will assess both the implementation progress and the efficacy of the programs toward meeting the plan goals.

The second element is the actual scientific monitoring that will rely on the collection and assessment of data from project area streams. These data will address the physical aspects of the Chinook salmon habitat and the changes in habitat conditions over the life of the plan. Like the first element, where data assessment indicates that program activities do not meet the plan goals, the City will need to modify its programs or else risk losing federal government protections.

Though the two elements are somewhat separate, the programmatic and scientific monitoring will be combined into a single report to submit to NOAA Fisheries. The last section of this chapter outlines how results from the programmatic and scientific monitoring will be integrated and presented to NOAA Fisheries. The monitoring plan to be submitted will include the declaration of compliance with ESA Section 4 (d) Rule requirements for continued certification, the monitoring data that demonstrates compliance, and, for those activities that may not be contributing toward the Section 4(d) Rule objectives, corrective steps to be taken.

PROGRAMMATIC MONITORING

Programmatic monitoring covers all the programs to be implemented to prevent habitat degradation and initiate restoration of PFC. As described in detail in Chapter Seven, the actual suite of program solutions to be implemented across three city departments and several divisions within each department is very complex and requires a well organized monitoring plan. In addition, there are citizen behavior activities to be implemented, which will likely impact in one way or another all the City program activities.

Not all program activities will be implemented simultaneously, nor will each activity be fully mature when initiated. The activities will be implemented over a multi-year period and develop and mature over time.

Activity implementation will be based on several factors including the type of activity to be initiated, funding necessary to finance the activity, ancillary activities that may be necessary to support an activity, and the logistical mechanisms (departmental and political support, staffing, supplies, etc.) that will need to be in place before the activity can be implemented. Consequently the following steps will be taken to monitor these programs.

- Development of a timeline and implementation schedule,
- Identification of activity initiation and subsequent milestone steps to meet the implementation schedule, and
- Identification of goal achievement – ultimate goal(s) and interim goal(s).

Implementation Timeline and Milestones

There are approximately 43 activities that the City will implement as part of the plan. Many of them are made up of multiple elements or "sub-activities" that will need to be implemented before the activity is fully effective. With such a large number of activities, the timing of their implementation will be critical. Therefore, the plan will need to include a master schedule that can be used as an activity-initiation checklist.

As mentioned, not all activities will be initiated at once. Activities related to changes or modifications to the City's zoning and land use development code are dependent on other ongoing projects (e.g., Goal 5 project, periodic review, etc.). Similarly, some activities that are related to the implementation of the City's Stormwater Master Plan are scheduled for implementation over several years, and need to be included in a comprehensive timeline.

In other instances, some activities cannot be implemented until another activity is implemented or even completed. For example, the retrofitting of existing City parks to reduce negative impacts to Chinook salmon habitat, if any, cannot take place until the Parks and Recreation Department completes its park inventory.

The timeline elements will include the following:

- 10 year time horizon divided into quarters,
- List of activities to be implemented categorized by department,
- Each activity will list an initiation date and the exact activities or "sub-activities" to be initiated. In many instances there is expected to be multiple dates as a program is initiated or expanded as it matures.
- Ongoing programs will be listed as such and will identify any additional activities to be included in the implementation period, and
- Activities with end dates or sunset dates will be noted.

Associated with the timeline and initiation dates will be a list of expected milestones. Milestones will be defined as those specific achievements that are related to the plan. Only those milestones that are specifically related to the plan will be included. The milestones will be itemized by activity and date they are expected to be met.

Identified Goals

A set of specific, measurable goals will be identified for each of the activities. These goals are critical because they will be compared to the progress that is documented in the monitoring assessment to determine overall plan progress. While the plan's ultimate goal is to prevent further degradation to Chinook salmon habitat and to secondarily initiate restoration of PFC, it is impossible for an individual activity to achieve that goal alone. It is the sum of the individual activities' goals that will result in the ultimate achievement of the plan. Consequently, it is expected that goals for individual activities will be very specific and likely differ depending on where the activity is in its implementation timeline.

It is important that the goals be measurable. While goals need not be quantitative, they should identify a specific achievement to be reached. For example, the parks inventory and assessment activity has the goal of identifying park design or structures that may have negative impacts on Chinook salmon habitat. Therefore, the measurable goal could be that the inventory will be conducted in phases with a certain number completed by each phase. The goals are specific and easily measurable.

Other goals may be more difficult to measure. Construction site enforcement is a good example of this type of goal. While it may be easy to quantify on-site visits by enforcement officials and the actions that they may take, a goal based on number of site visits and enforcement actions may not be a reasonable measure for compliance. Goals will need to be carefully considered in order to identify measurable goals for use in the monitoring plan.

Timelines and Goals Matrix

The activity timelines/schedules and goals will be combined to create a master matrix that outlines not only the schedule for implementation and the milestones expected by specific date, but also the goals to be achieved. This master matrix will become the basic tool used to evaluate programmatic progress.

The following steps will be taken annually to monitor programmatic progress:

- Collection of information on the programs that are initiated and the specific activities performed over the previous 12 months,
- Comparison of the activities initiated, and related milestones, to activities expected to be initiated in the master matrix,
- Determination as to whether the goals have been met and, if not, a determination of the degree of progress.

Once the initial monitoring assessment is completed and a determination is made for each program activity there will need to be an overall assessment that addresses what this means. This is important as it can help the City make choices, if needed, regarding how to move forward should program activities not meet their goals.

It could be that the City finds some activity goals are unrealistic or that some activities are more important that others. Again, the ultimate goal is to not further degrade Chinook salmon habitat and that meeting this goal is the sum of all the activities. Therefore, the failure or success of a single activity would not necessarily translate to failure or success of the plan itself. Since it will be the actual scientific measurements (see the next section on the Chinook salmon habitat monitoring program) that will determine whether the plan is successful, it is presumed that implementation of programmatic activities will result in the scientific information showing that the plan's ultimate goals are met. Whether all activities must all be meeting their goals at all times is open to interpretation.

From a literal interpretation, a program that does not meet its goals is technically in need of corrective action. Steps to be taken to correct the activity direction would need to be identified and a timeline developed that would put the activity back on schedule. This should be done for the monitoring report.

From the practical standpoint, it may be that certain programs are more important than others and that if these do not meet their goals, the City, with limited resources, may decide to focus on the most important activities first. The approach to activities and their differential impact will be addressed in the last section of this chapter.

Programmatic Reporting

From the standpoint of the monitoring program and reporting, all activities will need to be evaluated equally in order to assess the progress of an activity from year to year. Once the activities are assessed and a determination is made as to whether an activity has met its goals, the programmatic portion of the monitoring report can be prepared.

The programmatic report will include the following sections:

- Matrix showing, for the year in question, the schedule of activities to be initiated or performed, their milestones and expected goals,
- The actual assessment of what each program has accomplished,
- The comparison between goals and actual accomplishment, and
- Corrective steps and a schedule to bring activities that do not meet their goals back into line.

CHINOOK SALMON HABITAT MONITORING PROGRAM

Objectives

Stream monitoring generally results from questions concerning the impact of land cover and land use activities on water quality and system health, and the desire to predict outcomes from any changes. These may involve increases in runoff through changes in vegetation cover type, or increases in impervious surfaces altering sedimentation patterns, sediment fluxes, and chemical inputs to the streams. Other human activities causing changes in stream health include flow removal and alteration for drinking water, irrigation, and hydroelectric power generation. The monitoring objective, type of problem (for example, nutrients versus toxic metals), and use of information (for example, a local management question versus legal litigation) determines the necessary stage of analysis. As part of its Salmon Response Plan, the City must develop a monitoring plan to assess the impact of any activities by the City to ensure compliance with the ESA, as well as the outcomes of any rehabilitative projects undertaken.

The stream habitat baseline assessment completed as part of Phase 1 of the ESA 4(d) Program forms a critical element of the monitoring effort for the City. The stream reaches identified in the Corvallis ESA 4(d) Assessment Phase 1 Report contain the monitoring points. This project identified representative sampling transects and collected baseline data using the methodologies described by United States Forest Service (USFS) Level 2 Stream Habitat Analysis, USFS Guidelines for Establishing Stream Reaches, and the Oregon Department of Fish and Wildlife (ODFW) Stream Habitat criteria.

The ESA habitat assessment sampling established GPS-monumented transects with the reaches to facilitate return to the same locations for monitoring. The study measured five cross sections, using channel width and depth at 0.5 m intervals, for each reach. In addition, the study identified existing instream habitat types within each reach, measured erosion, substrate type, percent cover, amount of overhang, and shading. As well, the City placed 12 thermistors (temperature gauges) in selected locations in each of the urban stream systems in the summer of 2001. These gauges provide an hourly record of temperatures at each location (see Figure 4 and Tables 4 and 5 for map and locations of GPS transects and thermistosr).

This initial baseline assessment, in combination with the City's current temperature and water quality sampling, measures most of the necessary parameters, paying close attention in the study design to the seasonality and natural variability inherent in each variable. The pathways analysis established the parameters of interest for monitoring purposes. These consist of channelization, instream habitat, impervious surface, riparian areas (buffers), and barriers to fish movement.

Figure 4. GPS Transects and Thermistor Locations

See separate file

Table 4. GPS Transect Locations

Identification Label	Down Steam Point		Up Stream Point	
	Latitude	Longitude	Latitude	Longitude
DuCSFR1 T1	44.54818	123.29968	44.54794	123.30085
DuCSFR2 T1	44.55043	123.30997	44.55100	123.31099
DuCSFR3 T1	44.55142	123.31224	44.55136	123.31364
DuCR1 T1	44.55280	123.27928	44.55222	123.27976
DuCR2 T1	44.55038	123.28030	44.54988	123.28134
DuCR3 T1	44.54925	123.28489	44.54898	123.28510
DuCR4 T1	44.54974	123.28983	44.55005	123.29097
DuCNFR1 T1	44.55395	123.29337	44.55405	123.29468
DuCNFR2 T1	44.55692	123.30031	44.55751	123.30089
OCR1 T1	44.55492	123.27821	44.55498	123.27925
OCR2 T1	44.55646	123.28096	44.55688	123.28194
OCR2 T2-	44.55927	123.289457	44.560187	123.289517
OCR3 T1	44.56591	123.299571	44.566511	123.30062
OCR3 T2-	44.57072	123.30914	44.57104	123.31030
OCR4 T1	44.57135	123.31230	44.57137	123.31349
OCR4 T2	44.57612	123.32648	44.57682	123.32731
OCNTR1 T1	44.57192	123.31089	44.572809	123.31066
OCNTR2 T1	44.58653	123.30796	44.58730	123.30815
OCNTWF T1	44.58100	123.30867	44.58936	123.30940
OCNTR3 T1	44.59001	123.308309	44.59078	123.30914
DCR1 T1	44.57472	123.25347	44.57471	123.25452
DCR2 T1	44.57346	123.26357	44.57424	123.26379
DCR2 T2	44.57662	123.26826	44.577255	123.26912
DCR3 T1	44.58522	123.27454	44.58532	123.27580
DCR4 T1	44.58957	123.28201	44.59021	123.282641
DCWF T1	44.59188	123.29665	44.59236	123.29767
DCWF T2	44.59597	123.30370	44.59656	123.30409`
DCMF T1	44.59340	123.28559	44.59359	123.28667
DCMF T2	44.59613	123.29050	44.59685	123.29097

Table 4. GPS Transect Locations

Identification Label	Down Steam Point		Up Stream Point	
	Latitude	Longitude	Latitude	Longitude
DCEF T1	44.59328	123.28406	44.59398	123.28463
DCEF T2	44.59481	123.28507	44.59566	123.28526

Table 5. Thermistor Locations

Identification Label	Thermistor #	Latitude	Longitude
SQC13	5508	44.54796	123.30050
SQC14	5507	44.55282	132.27977
OC7	5506	44.57646	123.32702
OC8	5504	44.57141	123.31193
OC9	5503	44.57141	123.31193
OC10	5505	44.57137	123.31071
OC11	5502	44.55664	123.28180
OC12	5501	44.55495	123.27918
DC3	5500	44.59191	123.29693
DC4	5498	44.59350	123.28587
DC5	5499	44.57806	123.26986
DC6	5497	44.57472	123.25335
SEC1	4296	44.60041	123.26248
SEC2	4292	44.59020	123.24506

Monitoring of changes in the riparian buffer will use both the existing ESA project data and the NFI riparian species identifications. Unfortunately, the lack of any quantitative survey work precludes use of most of the NFI database. The baseline analysis, when combined with those elements of the NFI project, allows the prediction of the trajectory of current habitat effects succession as changes occur. Determination of succession uses analysis of historic changes and current conditions to predict the future. This facilitates determining the fate of the various habitat elements, as well as developing correlations between natural and anthropogenic conditions and habitat effects.

Monitoring variables of interest include flow, stream geomorphology, high flow turbidity, nutrients (nitrogen, phosphorous), pesticides (including insecticides and herbicides), industrial chemicals, and heavy metals. This focuses chiefly on the contamination and habitat pathways. There exists sufficient background knowledge of these parameters to formulate correlations with existing land cover/land use (LC/LU) patterns, and to predict the expected direction and magnitude of changes. The plan need not measure dissolved oxygen or any biotic parameters, unless nutrient measurements increase during the low flow season, indicating potential for anoxic conditions. The plan should have a structured sampling periodicity to fit both the proposed changes in LC/LU activities and the periodicity expected from each of the water quality variables.

The overall goal for monitoring consists of shifting the above-mentioned parameters toward PFC when possible, or allowing no further degradation. PFC refers to the retention of the underlying habitat-forming processes while changing the inputs to achieve a system functioning in a manner beneficial to fish. Urban systems present the greatest challenge to obtaining PFC, as they contain a great deal more "constraints", which restrict rehabilitative actions.

Monitoring Study Design and Approach

Monitoring of stream ecosystems to determine if some impact has significantly altered the integrity of the stream or site in question requires the determination of the appropriate scale of inference. For example, to describe the physical and biotic components within the ecoregion, sample sites should represent the types of streams occurring within that spatial scale. Selecting sampling locations involves two different processes. First, is the selection of sampling reaches. This involves selecting reaches that are representative of the spatial scale of inference and that conform to the statistical design. Second, is the choice of sample site locations within the reach. Sample locations depend on the statistical design and the particular factor to be measured.

The balance of this chapter is divided into two sections. The first section addresses the important scientific concepts that form the basis of the ESA Section 4(d) Rules monitoring study. It covers the methodological underpinnings of monitoring, sampling procedures, periodicity, time series and multiple sites, and water quality analysis. The section concludes with a brief discussion of monitoring design and interpretation of monitoring data that are collected. Without a properly designed monitoring plan, it is possible to introduce interpretation error.

The second section describes the monitoring plan to be implemented. It identifies the data to be collected, the evaluation procedures to be performed and the comparative process that is designed to determine effectiveness of the ESA Section 4(d) Rule plan.

Classification Methodology and Background

Stream classification provides a means of stratifying streams and identifying sampling locations that addresses the spatial scale of inference and objectives of the monitoring program. A spatially nested hierarchical framework for classifying stream systems allows managers to identify the spatial scale of inference (Frissell et al. 1986; Hawkins and others 1993; Maxwell et al.1994). In a hierarchical system, lower levels are modified and constrained by factors operating at higher levels. Therefore, an attempt to focus on factors influencing stream ecosystems on a small scale requires awareness of factors operating at larger scales. One cannot evaluate and manage to alleviate the effects of riparian removal when similar or other impacts occur throughout the watershed. The methodologies below provide both the theoretical and technical underpinnings for this understanding.

Watershed Scale

The ecoregion exists as the upper level of the hierarchy. Successively lower levels consist of streams, stream segments, reaches, pool/riffle complexes, and microhabitats. Each hierarchical level permits refinement for more precise classification. Inclusion of flow regime further refines the biogeoclimatic aspects and relates to flow, a major environmental driver of stream/riparian ecosystems. Corvallis lies within the Willamette Valley ecoregion, characterized by generally mild climatic conditions, with streams having seasonal flows consisting primarily of rainfall runoff.

Classification requires distinguishing between "regional" versus "local" for climate, geology, and terrestrial vegetation. Proper classification at the watershed level uses the availability of long-term records of atmospheric temperature, precipitation, and stream discharge to develop the information base for these contrasts. Incorporation of thermal regime permits stratification by catchment-level differences. Catchments similar in external or regional biogeoclimatic controls often differ in their thermal environments because of different make-up combinations of ground and surface water or different aspect of orientation to the sun.

The following discussions place the Corvallis area in its appropriate regional context. Foothills dominate the northern and western parts of the city separated by smaller stream corridors and valleys, flowing east to the Willamette and Mary's Rivers. The hills have moderate to steep side slopes (10 to 25 percent). Floodplains and terraces rise stepwise from the Willamette and Mary's Rivers towards the Corvallis foothills.

The Willamette and Mary's Rivers create the two major hydrologic basins within the study area. Dunawi and Oak Creek, both tributaries of the Mary's River, drain the western part of the city. Other small, perennial streams discharge to the Willamette River, (Dixon Creek, Jackson Creek, Frazier Creek, Lower Booneville Channel, Sequoia Creek, Stewart Slough and their tributaries).

Upland soils mainly comprise moderately deep, well-drained silty clay loams and shallow, well-drained silty clays, with minor amounts of clay loam, clay, and silty-clay. Association on the slopes and upper terraces developed on mixed alluvium from glacial outbreak floods in well-drained locations and contain moderately well-drained and well-drained silt loams. A series of poorly drained clays dominate in the lowland areas, preventing significant infiltration of rainwater.

Stream Classification

The lower spatial scales depend upon analyses performed at the reach- and point-scales, and require classification of the segments in order to establish correlations suitable for statistical evaluation. As well, the classification methodologies, particularly Rosgen's approach, provide an excellent diagnostic basis for assessing stream changes, or in combination with other techniques (Montgomery-Buffington 1993) provide a quantitative approach for assessing the likelihood of rehabilitation project success.

Classification of stream segments uses conventional geomorphology practices based on either tributary junctions, or major geologic discontinuities or both. Rosgen (1996) provides criteria for distinguishing stream reach classes. Important habitat-forming processes at the stream reach level include sediment budgets (substrate type) and large woody debris (LWD).

Valley and channel features (Rosgen 1996) further characterize the physical environment. Channel slope (gradient) influences current velocity, turbulence, and substratum composition. Valley form uses the degree of entrenchment; the ratio of flood prone width divided by bankfull width. Bed form indicates whether the channel is straight, braided, or meandering. Sinuosity, the ratio of channel length to valley length, indicates the extent of meandering by the stream. Width/depth ratio, width at bankfull stage divided by bankfull depth, measures the distribution of energy within channels. The use of valley form (Rosgen 1996) in place of side-slope gradient better characterizes features important to riparian as well as stream dynamics at this classification level. Classification of pool/riffle systems provides important descriptions of the desired fish habitat features.

Sampling Design

Effective outcome-based monitoring of a project or process requires the establishment of cause-effect correlations between actions and results. This makes the use of statistics to establish a quantitative basis critical. The use of "best professional judgment" especially needs the support of a quantitative sampling program and the resulting correlations, even if it fulfills the regulatory agency requirements. Developing this sampling program requires knowledge of sampling frequency at different temporal scales. For instance, larger scales deal with the scale of inference determined by the sampling objectives and the spatial level of disturbance or interest. The smaller temporal scales address the sampling frequency necessary to adequately characterize the factor measured. This depends on the factor and stage of analysis.

Natural landscape disturbances of a given frequency generally occur at a particular spatial scale; the longer the recurrence interval of a disturbance, the larger the spatial scale, and the higher the system organizational level of the system (O'Neill et al. 1986). For example, in the Pacific Northwest small forest fires occur frequently but over small areas. Fires occurring over larger areas have much longer recurrence intervals. The relationship between natural spatial and temporal scales of disturbance helps determine sampling frequency.

Corvallis Stream Habitat Sampling

Sampling to obtain background or reference data uses the scale of inference (spatial scale) to establish sampling frequency. For example, at the ecoregion scale of inference with sites stratified by stream order, sampling should occur annually at first-order sites, every other year at third-order sites, and every five years at sites greater than fifth order. Small order sites drain a smaller area than large-order sites. Therefore, stream conditions likely will vary on a shorter temporal scale and require more frequent sampling to document natural variability.

The temporal scale of the Corvallis ESA monitoring effort should continue to measure and replicate stream physical habitat and cross sections yearly to determine the changes associated with conditions in the stream. The interpretation of these data requires caution, however, as even in a system not influenced by human activities, these parameters change through time. The cross-sections should change gradually, as part of the stream's evolution. Any dramatic changes in the lower reaches over a 5-year time span indicates both a lack of stream equilibrium and the continued presence of inputs that caused the shift away from "typical" stream evolution. These include inputs of stormwater runoff such that the streams continue to downcut. If these inputs decrease, the City should expect a gradual decrease in depth as the stream adjusts its sediment deposition accordingly.

The reaches high in the system will likely show changes in stream cross-section, as the incision progresses more quickly initially as the result of continued increases in overland transport of stormwater runoff and the presence of relatively easily-eroded soils in proximity to and within the stream channels. The baseline study considered this when planning the sampling design and placed cross-sections in areas expected to show changes quickly in respect to changes in corresponding land use. The rate of change, rather than the amount of change, will provide more information on the effects of any City-initiated changes in land use or operations.

Site Selection for Evaluation of Point and Non-Point Actions

Monitoring to determine possible impacts usually involves comparing impacted sites with reference sites. Reference sites replace the more rigorously defined "controls" of a laboratory experiment and create many problems associated with the validity of comparisons. Reference sites generally consist of either a similar location upstream of the disturbance (for small-scale impacts), the same location prior to disturbance, or a similar site or sites located on a different stream or streams (either historic or contemporary data). The selection of impact and control sites varies with the spatial scale of the disturbance. If the disturbance affects an entire basin, comparisons would use historic data (same location or different location within the ecoregion) or data from other streams in similar basins.

Effective management of local ecosystems (for example, stream reaches or watersheds) requires attention to the landscape in which they occur. In general, the City should confine any reach comparisons to within-watershed. Should cross-watershed comparisons prove necessary, the City should restrict them to reaches with similar gradient and longitudinal stream position. The City should use similar criteria for establishing monitoring of changes in instream habitat type as it, too, evolves with the stream geomorphology.

The following example outlines the dangers inherent in sample site selection and spatial scales. The same cautions hold true for temporal scales. Assume the random selection of sample sites from any sized stream (first to fourth order), and any segment of these streams (confined high slope to unconfined shallow slope). Despite the high degree of variability in these data, this sampling design provides a means to distinguish differences among ecoregions, while not allowing the comparison of differences among locations within the ecoregion. Sample sites located on steep-sloped first order streams cannot provide data representative of all streams within the ecoregion nor does it allow comparisons of stream reaches contained within different kinds of stream segments, systems, or ecoregions. One would not compare physical data obtained from a large river with similar data from a small headwater stream.

No matter what spatial scale of disturbance, reference sites should have as similar a classification to impacted sites as possible, not necessarily proximity to impacted sites. Proper and similar classification of impact and reference reaches ensures viable comparisons. Decisions concerning sample site location depend on the study design and the nature of any statistical comparisons. Comparative data require the selection of a sampling location that provides the best measurement of the parameter. For statistical comparisons all suitable locations within the reach should have an equal probability for being selected as sampling sites.

The relationship between spatial and temporal scales also facilitates impact evaluation. For example, climate operates at the spatial scale of a watershed or ecoregion. Impacts at this spatial scale (depending on intensity) influencing stream systems at a temporal scale from 10 to 100 years necessitate monitoring every few years rather than monthly. However, citywide operations warrant an annual monitoring regime with monthly sampling during the summer months to evaluate such outcomes as influence of facility practices on water quality.

Selection of the appropriate temporal scale of operation facilitates the selection of the optimal sampling frequency to characterize the variability in stream structure and function. Any differences observed between treatment and control sites may suggest the presence of suspected problems, but only sampling for multiple years or comparison to long-term sampling locations can confirm that the differences represent changes outside the normal condition.

The frequency of sampling depends on the parameter and the stage of analysis. The characterization of the variability of same parameters of interest requires only annual sampling (e.g. large woody debris and substratum size distribution) as they result from processes occurring at a longer time scale (bankfull or 2-year flooding). As bankfull flows generally occur during annual rainfall periods for Corvallis streams, more frequent measurements of these parameters prove unnecessary. Most of the parameters measured vary throughout the year and sampling frequency increases with the stage of analysis to better characterize these changes.

Statistical Design

A monitoring program usually attempts to determine differences between treatment and reference sites, or correlations (cause-effect) between variables of interest and activities. Determining this successfully depends on the action under investigation and often requires statistical comparisons. All the variables of interest rarely get collected, making the taking of a sample necessary. Sampling obtains a portion of the total population to use to make inferences about the total. Statisticians refer to the characteristics of the total populations as parameters, and an estimate of a parameter obtained from a sample as a statistic. For example, a statistic will include such calculations as the arithmetic mean obtained from the samples used to estimate the population mean. The more samples obtained, the more resemblance of the sample statistics to the population parameters.

If no need to sample existed (i.e., the observer has access to the entire population) simple parameter comparisons could determine any differences. However, as the analysis compares samples of the population, statistical analyses determine the probability of the samples from the reference and impacted sites representing the same population. The observer formally states this as a null hypothesis: no difference exists between impacted and reference sites. This statistical inference contains within it the possibility of committing two types of error. First, one could conclude that the samples come from different populations when in fact they do not. This represents a Type I error. Second, one could conclude that the samples come from the same population when they do not. This represents a Type II error. The problem lies in that by attempting to reduce one type of error, the other type increases. Since increasing the number of samples causes sample statistics to approach population parameters, increasing sample size helps reduce the probability of committing Type II errors.

Increasing the number of samples increases sampling and processing time and associated costs. Therefore, in selecting the number of samples taken, one attempts to increase confidence in statistical analysis while reducing time and costs. The exact number of samples required to obtain a certain level of confidence in the statistical analysis depends upon on the magnitude of difference in populations determined as significant by the observer, and the variability among samples. Bio-ethicists suggest that observers prefer the potential of a Type I error in cases involving only expense, and a Type II error in those cases containing risk to humans or animals of interest.

Statistical analytical procedures use parametric or nonparametric methods, each depending upon different assumptions and the underlying distributions of the variables in question. Parametric tests require meeting the following assumptions: random sampling from a normal population and equal variances. Data transformation can resolve problems associated with non-normal distribution and inequality of variance, but failure to meet these assumptions requires the use of nonparametric alternatives.

Sampling programs should measure chosen parameters at intervals of time and space reflecting the variability inherent in the system. The value in choosing somewhat conservative parameters lies in the ability to effectively capture their variability within the sampling program without prohibitive expenditures. However, the analytical process should effectively remove the background "noise" (e.g. natural variability associated with ecoregion-level processes) from the data through use of the existing background data sets. This allows the assessing and correlating of the "residuals" with associated watershed controls and processes, and the establishing of cause-effect relationships.

Single Site or Time Period Analyses

Assessing the difference between reference and impacted sites compares only two statistical populations: factors at reference sites and those at the treatment sites. Appropriate statistical tests for these comparisons include parametric t-tests or analysis of variance (ANOVA). Nonparametric tests include alternatives for continuous data, and chi-square tests for discrete data. The nature of some of the parameters of interest in monitoring allows for only qualitative comparisons. Data variation problems arise when comparing single- and two-sample sites. The variation determined by these small samples renders any inference concerning differences essentially impossible. Observers should conduct replicated sampling at each site to allow meaningful comparisons.

Multiple reference and treatment sites still represent only two populations: impacted and reference. However, variance in this case comes from a number of different replicate streams (or reaches) and should be treated with extreme skepticism despite similar classifications. Many of the factors measured vary considerably among differently classified stream reaches. For example small upland confined streams contain larger particles than larger floodplain streams. This inherent variability masks impact effects, increasing the chance of committing Type II errors.

Impacts occurring at discrete locations allow the use of a paired t-test as the statistical design (assuming assumptions are met). For example, multiple sites may potentially face impacts resulting from the presence of road crossings. Impacted sites below the crossing and reference sites above get paired, with the sampling statistic as the difference in factors between these two sites at multiple locations. This reduces the stream variability and reduces the probability of committing a Type II error.

Any monitoring of reach-scale restoration activities designed to improve contaminant levels will likely involve the following study design: an "upstream-downstream" model testing the hypothesis that any detected changes in the baseline result from a specific action or activity and attempts to obtain statistical correlations between or among actions and observed outcomes. Many point- and non-point-source monitoring programs use approaches that statistically evaluate change by examining differences in parameter means. These generally consist of data time-series analyzed using moving averages calculated over some time (typically seven days) of maximum or mean temperatures, measured upstream and downstream of a designated point-source or area of concern.

This upstream-downstream design presents severe statistical problems, especially in the assumptions used in the comparison of sites and determining the presence of significant changes in parameters as the result of some action. A more appropriate design than the simple paired before-after analysis uses Before-After-Control-Impact Paired Studies, which has a similar design, but rather than compare means from each data set, instead compares the variability in a time-series from each site. This allows the use of the same parametric or non-parametric statistical analysis procedures, but more appropriately reflects differences as the result of the "treatment" rather than pre-existing differences in variable concentrations.

Multiple Site or Time Series Data

Multiple years of data from both locations creates a study design analogous to multiple reference and impacted sites. In this case data variability comes from the same stream over time. Sampling during the same time interval, allows comparison of each year individually; beneficial for short-duration impacts or monitoring of management.

The presence of the time series of temperature data provides a useful baseline for the analysis of the influence of future land use changes on watershed health. Time series analysis applies a basic regression model to data collected between discrete times. This methodology uses the order of the observations to assess the past and future behavior of the variable(s). This provides some degree of both prediction of future behavior, and correlation with past events, occurring within the time series. Taking advantage of this predictive capability requires understanding the processes within the system, and estimating its parameters.

Time series regression allows the observer to use the data collection series to directly correlate the endogenous (dependent) variable, with the associated exogenous (independent) variables, or to "lag" the endogenous with the exogenous. The latter methodology uses dependence upon the past values of the latter to predict the current values of the former. For example, it may prove desirable to examine the influence of various factors on temperature. Exogenous variables include shade, groundwater, and the temperature of the upstream flows past a designated point. The upstream temperatures represent an exogenous variable that requires "lagging" to fully develop the correlation.

Further time series analysis models include "unreplicated" (before-after with a single intervention), paired designs (following the BACIPS model), and ARIMA models. ARIMA stands for auto-regressive integrated moving average. These represent the great majority of time series models found in the literature, especially intervention models. Intervention models examine the time series for responses to events. Detailed explanations of these methodologies go beyond the scope of this report, however, the statistical analytical procedures exist on most "canned" packages, and most advanced statistics texts contain detailed descriptions of the available models.

As an example, the nonparametric analytical procedure, the Seasonal-Kendall trend analysis available in the WQHydro statistical software package, requires a minimum of thirty data points to detect the presence of statistically significant trends at any given monitoring site. For each site, the data set gets divided into twelve subsets, one for each month, with the analysis of each of these subsets for the direction, magnitude, and significance of trends. The test compares these subsets and generates an annualized result, indicating the existence of any significant trend, and its magnitude and significance. This procedure also ensures the consistency of increasing or decreasing trends through time, and the separation of actual trends from normal seasonal variation.

Another non-parametric methodology, superposed epoch analysis, provides a useful methodology for examining the behavior of selected variables under changing controls, such as climate or geologic phenomena. The methodology requires simultaneous collection of biotic or physical parameter data and simultaneous information on the control variable(s) of choice. The analytical procedure uses a non-parametric ranking methodology, such as Spearman's rank, to organize the data of interest. This methodology provides a suitable approach to data analysis at the landscape or similar such hierarchical level. This provides, perhaps, more statistical power than necessary for the project, although some utility may lie in analyzing the outcomes of larger time scales.

Multivariate analyses also apply in some situations. Treatment sites often vary in intensity and treatments vary directly or over time. Parametric analysis of variance (ANOVA) or a nonparametric alternative (Kruskal-Wallis) could determine the effectiveness of a management action, with each year representing a separate factor. Likewise, correlation between stream condition and years since the action could also evaluate management actions. In this case, treatment intensity changes with time.

Corvallis Water Quality Monitoring

Water quality sampling for the monitoring program should begin with the first significant rainfall and continue during the next several storms, in order to assess the timing and amount of inputs to the stream systems. Sampling should also include the summer low-water period to assess residence time of various compounds.

The United States Geological Survey (USGS) North American Water Quality Assessment (NAWQA) program used Dixon Creek as one of its study streams. The chemicals found in it placed it in the non-agricultural category. These included Carbaryl (Sevin), used for both home and landscape applications; Dichlobenil (Casoron) and Tebuthiuron, used to control broadleaf weeds, and under asphalt and railway rights-of-way (ROW); Diazinon, uses similar to Carbaryl; and Prometon, used in urban landscaping, ROW, and industrial applications, and by homeowners. Dixon Creek also exceeded standards for temperature, fecal coliform, and *E. coli* bacteria. It appeared to have no excessive nutrients.

Dixon Creek likely carries the "usual" urban runoff components of metals, other organic compounds, and petroleum products. Indeed, a study done for the City of Salem by the USGS found excessive levels of lead, zinc, DDD, DDE, DDT, and several polycyclic hydrocarbons. This data set should provide Corvallis with guidance as to what to expect in its urban streams. As a result, good data on most of the water quality parameters already exists and should function extremely well as the baseline for assessing the impact of City actions and its citizen's behaviors on the streams of the area.

Oak Creek, as the result of the agricultural land uses on the middle reaches, may require a baseline more skewed toward nutrient levels. Dr. Stan Gregory of Oregon State University (OSU) has initiated a N^{15} study in Oak Creek that should prove very useful. Despite a long-term focus on the problem of herbicide transport in surface runoff from agricultural application, until recently little detailed investigation of the transport of herbicides in surface runoff from roadside applications exists in the literature. Because of the NAWQA program, the USGS measured the concentrations of urban, rural, and forest chemicals in select water bodies across the country.

The water quality variables measured by the NAWQA program, and the others mentioned earlier should comprise the extent of the City's water quality assessment. See Appendix 10 for a discussion of the nature of these parameters and their expected spatial and temporal variability.

Models for Sample Design and Data Interpretation – Contamination Transport

Most of the basic theory of herbicide entrainment and transport in runoff information and models apply directly to the other applications, despite its major development in an agricultural context, particularly those related to the time periods following application (rainfall timing, intensity, and duration, and total runoff volume/pounds). The first significant runoff nearly always removes the greatest amount of compound. An often almost exponential decline in the total amount of the compound removed, as well as the runoff concentration with subsequent events, follows this initial rainfall event.

The availability of a compound for transport usually declines with time, even in the absence of precipitation, through

1. A decrease in the total amount of compound stored in the surface layer of the soil (degradation),

2. A decrease in the readily mobilized fraction through slow, progressive adsorption onto the soil matrix, and/or

3. A migration to more strongly binding adsorption sites. A longer lag time between compound application and the first runoff event decreases the amount of the compound removed by that event.

Cautions – Temperature Data

The City should also take care in the analysis of temperature data, as the recent literature on stream temperature demonstrates that measurements taken in a reach represent the outcomes from actions or conditions just upstream. Any monitoring of reach-scale restoration activities designed to reduce temperatures should first have the analysis of the baseline completed so as to characterize the parameter's variability, then monitor downstream of the activity. Any comparisons made among and between months at any or all sites should consider this.

Conclusion

In conclusion, a plan for ESA outcomes should establish the spatial and temporal scale(s) of interest for monitoring using the approaches described above. The study design should specifically establish sampling sites for the collection of nutrient and other water chemistry data on a temporal scale that would allow correlations with point and non-point sources at each level of interest, similar to the suggestions discussed in the chapters on each and the information on variability of each potential parameter in Appendix 10. The City's sampling program for water quality should allow the development of statistically defensible correlations between LC/LU changes and variations in the parameters of interest using the statistical approaches described above. Numbers of samples taken should reflect the hypothesized variability of the parameter in question, to establish background variability. This permits the testing of the hypothesized cause-effect relationships and a determination of their strength.

COMBINING PROGRAMMATIC AND SCIENTIFIC MONITORING

Both the programmatic and scientific reports will be integrated before forwarding to NOAA Fisheries. While the monitoring activities will be done separately, they will needed to be combined in order to make a declaration to NOAA Fisheries as to whether the plan is meeting the ultimate goal of no further degradation and restoration of PFC.

As noted earlier, the final determination as to the success of the plan will be based on the scientific information that is collected. If for some reason all the programmatic activities are failing to meet their goals yet the scientific monitoring indicates that there is no further degradation, the City could conceivably declare they are in compliance with the 4(d) Rules. The contrary, however, cannot happen. Scientific monitoring that shows further habitat degradation no matter the programmatic activity success will result in a declaration of non-compliance.

It is doubtful that either scenario could happen, though, because programs have been put into place that, when implemented, will meet the ultimate plan goals as reflected in the scientific monitoring. So, the monitoring plan must be integrated to demonstrate that the City is making progress toward the ultimate goal as reflected by the scientific monitoring and that the activities implemented meet the considerations listed under the ESA Section 4(d) Rules Limit 12 (Municipal, Residential, Commercial and Industrial Program development).

The final report will have the following contents:

- Programmatic monitoring section with the schedule and milestones for the monitoring year, measurement of actual progress for each activity, comparison between the expected and actual progress, determination of corrective actions, if any, and actual corrective action plan.
- Scientific monitoring will outline the factors and the measurements that will be necessary to be maintained for compliance, the actual data collected for each of the factors, the comparison between actual and expected, determination of corrective actions, if necessary, and actual corrective action plan.
- Declaration of whether the plan is meeting the ultimate and secondary plan goals.

The declaration is the most important section in the monitoring report because it is an overall statement of the ability of the City to meet the plan goals. Does failure to show that all scientific factors meet the required measurements mean that the program is out of compliance? How many factors must fail before the program is out of compliance? What about temporal changes, where some factors maybe out of compliance one year and another set the next? The point of these questions is to raise the issue that the monitoring program will have an interpretive component. That some scientific factors do not meet standards that prevent further habitat degradation might be acceptable in the short run if the program activities that influence the scientific factors do prevent habitat degradation in the long run.

It will be critical in the monitoring report to explain why project activities or scientific factors do not comply with the monitoring goals. That failure of a program to meet the goals is not a failure of the program itself. For instance, it could be that a program activity, such as a stream restoration, may have a long-run benefit to salmon habitat, but that it will take some time for those benefits to be seen in the monitoring plan. While the program activity is maturing, there may be a period when scientific factors do not meet the goals.

Therefore, the declaration section will carefully explain those programs that may have interim goals that could violate the monitoring goals, but in the long run will meet those goals. There will, of course, be programs that may not meet their goals and will need corrective action. For these activities the monitoring plan will describe the steps to be taken to put them back on schedule.